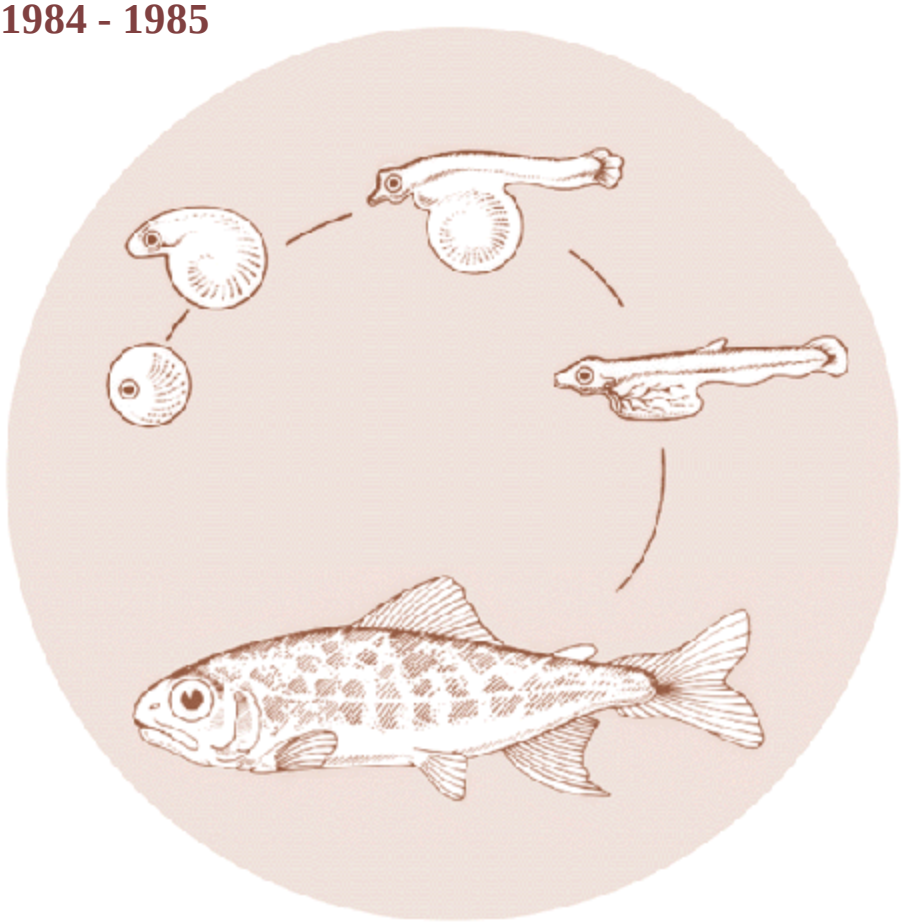
Protection of Wild Adult Steelhead in Idaho by Adipose Fin Removal

Annual Report
1984 - 1985



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PROTECTION OF WILD ADULT STEELHEAD IN IDAHO BY ADIPOSE FIN REMOVAL

Annual Report

by

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ABSTRACT

All Idaho hatchery-reared steelhead released in the spring of 1985 received an adipose fin clip to differentiate between natural or wild and hatchery fish, thus allowing for protection of wild fish in the sport harvest. Between 25 September and 14 December 1984, 6,360,542 steelhead trout (Salmo gairdneri) were marked by excising the adipose fin. A total of 10,336 man hours were required to complete the operation.

Clip quality and healing, mortality, and adipose fin composition were determined. Quality checks indicated less than 1% of the fish had more than 25% of the fin remaining. Combined mortality at all three hatcheries was 0.3% of the total fish marked. Observed and in vivo test showed complete healing of the excision within 3-4 weeks (observed) and 22 days (in vivo).

Bibliographies were compiled for fin regeneration, marked fish survival, hooking mortality, and related catch-and-release studies.

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INTRODUCTION

The improved survival of hatchery-reared steelhead in recent years has created serlous stock management problems. Hatchery-reared steelhead present harvestable surpluses, while wild stocks remain at low levels. Angling pressure directed on hatchery stocks could overharvest wild stocks. To differentially harvest hatchery and wild stocks in a sport fishery, various external identiflers have been used. Because hatchery fish are usually raised in concrete raceways under more crowded conditions than their wild counterparts, the presence or appearance of various fins have been used to distinguish between hatchery and wild fish. The presence of fins with reduced size or deformation usually indicates hatchery fish. In Idaho, several regulations regarding dorsal fin height have been used to separate wild and hatchery fish. However, these regulations apply to a small geographical area and have not proven successful in fisheries statewide. in an attempt to find a better external mark, fishery scientists have utilized an adipose fin clip to identify hatchery fish. This mark can be applied easily to hatchery fish prior to their release, is permanent if done correctly, and is easily recognizable by anglers. It is also considered to be essentially harmless since the adipose is believed to be without physiological purpose.

The objectives of this project were to:

1. Remove the adipose fins from all Idaho hatchery steelhead.

2. Review current information on the use of adipose clipping.

3. Determine the physiological role of the adipose fin if possible.

METHODS

All steelhead reared in Idaho hatcheries for release in the spring of 1985 were marked with an adipose clip. The mark operations were conducted in mobile marking facilities specially designed to efficlently handle the large number of fish and reduce marking stress (Duke 1985).

Fifty fish samples were randomly taken throughout the clipping operation to determine the quality of the clip. Fin clips were evaluated into five categories: excellent (100% removal); too deep (100% removal, but with secondary infections or complications possible); poor (less than 10% remaining at the leading edge); partial (l0-25% remaining); and not clipped (more than 25% remaining) (Fig. 1). All clip categories except "not clipped" are felt to be good enough to be used to identify returning adult fishes.

Fish health was monitored throughout the rearing cycle and any mortalities were noted. Final mortality attributable to marking was

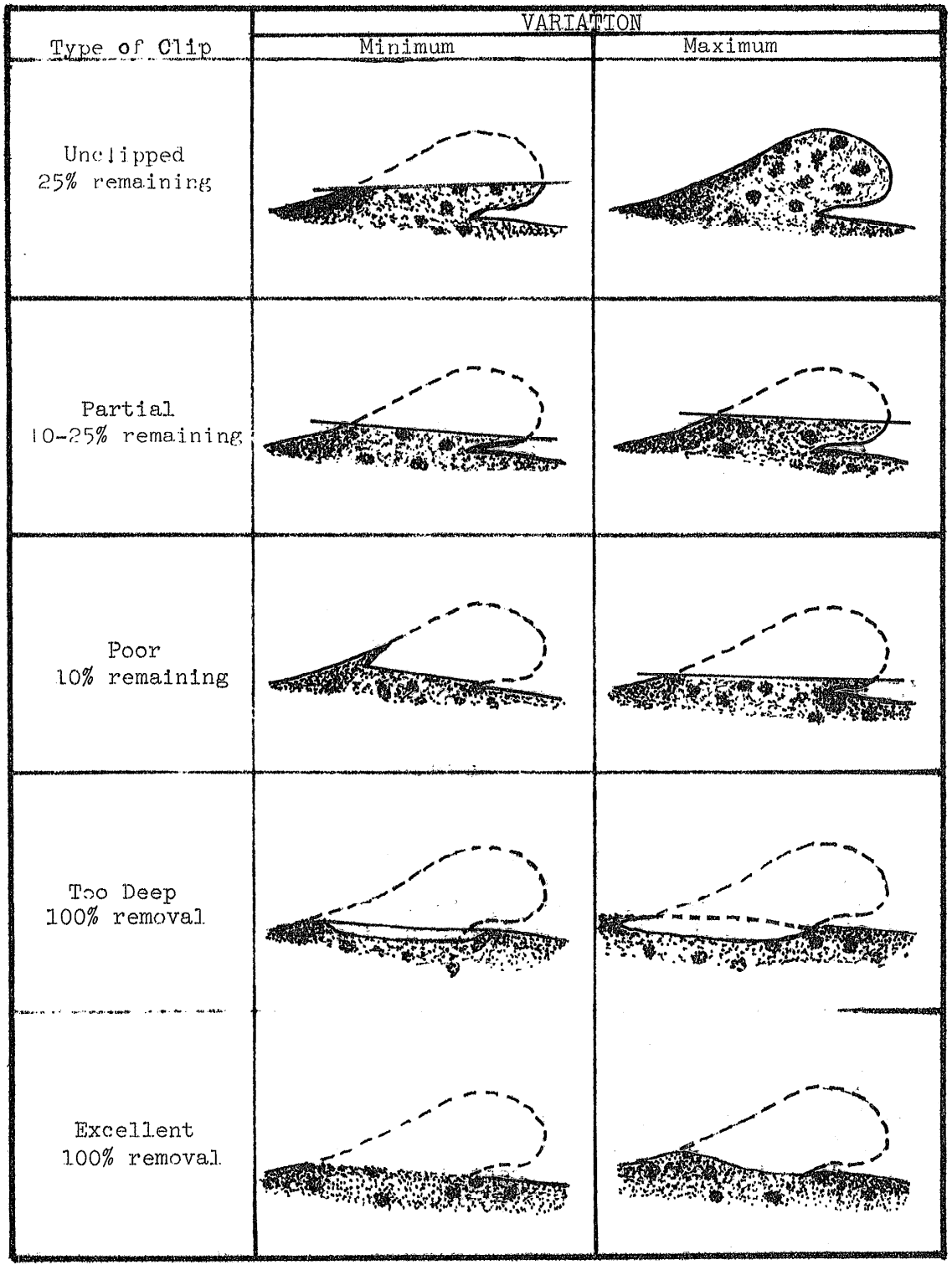

Figure 1. Adipose clip quality rating system for Idaho steelhead hatcheries; based on visual inspection.

calculated by subtracting the daily mortality before marking began from the mortality level after marking until the mortality rate stabilized at daily pre-marking levels, In some cases, rearing histories from the previous year were used to estimate the normal daily mortality rate for that particular stage of rearing.

In vivo experiments on healing rate were conducted at Dworshak National Fish Hatchery. Both unclipped (control) and clipped (test) fish were held. In addition, different types of clips representative of the five categories of clip quality were held to test differences in healing and to see if rejuvenation occurred. Idaho Department of Fish and Game (IDFG) personnel monitored the tests and documented the healing process photographically at set intervals, Additional tests were started at Niagara Springs Fish Hatchery but had to be discontinued because of holding problems.

Samples of juvenile and adult adipose fins were sent to the U.S, Fish and Wildlife Service Fish Cultural Development Center. Charlie E. Smith, Director, examined histological sections for tissue composition.

I did extensive reviews of literature on hooking mortality rates, present use of the adipose fin marking system, significant information gaps regarding this marking system for the protection of wild fish, adipose fin function and composition, and effects of fin clipping on survival. Literature references were gathered from various libraries, reference services, and personal communications with colleagues. Bibliographies for fin regeneration, effect of fin marking on survival, and hooking mortality and related studies are found in Appendix A, B, and C, respectively.

RESULTS

Mark Operations

The 1984 mark season started at Hagerman National Fish Hatchery 25 September and concluded at Dworshak National Fish Hatchery on 14 December. A total of 36 work days (10,336 man hours) utilizing two trailers and two 8-hour shifts of 16 workers each shift were required to mark the 6,360,542 steelhead trout at Idaho's facilities, Table 1 summarizes the marking operation.

Quality Check

A sample of 9,947 fish of the total 6,360,542 or 0.16% were checked initially for clip quality. A second quality check was taken at Hagerman National and Dworshak National fish hatcheries in April prior to release. The necessity of limited handling just prior to release

Table 1. Summary of Idaho steelhead adipose fin mark operations, 1984-85.

	Hagerman National Hatchery	Niagara Springs Hatchery	Dworshak National Hatchery	Total
No. fish marked	1,421,694	2,502,125	2,436,723	6,360,542
No. of days.required	8.5	12.5	15.0	36
Total no. marker hours	1,896	2,971	3,315	8,182
Total no. netter hours	264	564	445	1,273
Total no. supervisory hours[a]	240	336	305	881
Total man hours	2,400	3,871	4,065	10,336
No. fish clipped/marker day[b]	5,999	6,737	5,880	6,219
No. fish/man hour	592	646	599	615
Total mortality	3,025	11,710	1,660	16,395
Percent mortality	0.2	0.5	0.5	0.3

[a]Includes setup and cleanup.

[b]Marker day = 8 hrs. (includes 1/2 hr. total break time).

[c]All daily and hourly figures Include 8 hrs. of paid holiday time for each employee during this operation. Actual work days were 11.5.

restricted the sample sizes to 207 and 705 fish, respectively. Table 2 summarizes the quality checks.

No descaling was found during the operation. The fish were still small and in a pre-smoltification period when the scales are not deciduous. Prior to release, the fish were again checked. Some scale loss was observed, but was not attributable to the adipose marking operation.

Healing of the Clip

Observations of fish in the raceways at all hatcheries indicated complete healing of the tissue in the area of excision within 3-4 weeks. Fish that had been clipped too deeply usually showed signs of fungus within one week. There were also observed cases of nipping at the excised white area. In severe cases, fish with fungus died and accounted for the largest percentage of the observed delayed mortality. Mortality from this cause ended within four weeks. Observation from the in vivo test at Dworshak National Fish Hatchery indicated healing was rapid and complete within 22 days (Pat Chapman, IDFG, personal communication). From observation and photographs there was no apparent difference in the various full and partial clips in terms of regeneration or healing.

Mortality

Mortality was greally reduced this year primarily because the marking was done in the fall. For example, mortality of fish marked in the spring at Hagerman National Fish Hatchery last year was 26,000 fish due to the fin clip operation. The fish were extremely large (4-6/lb) and smolted. This year we marked in the fall and experienced only 3,025 mortalities. The fish were 33-38/lb, and smoltification had not taken place. There was also no indication of descaling. The previous year, descaling was believed to be a large contributor to secondary infection and subsequent high mortality. Table 1 summarizes the mortalities at each hatchery.

Adipose Fin Histogical Examination

Histological analysis for both juvenile and adult steelhead trout showed the adipose fins to be composed primarily of fibrous connective tissue interspersed with few blood vessels and occasional adipose (fat) cells. Special connective tissue stain demonstrated a high percentage of collagenous fibers typical of fibrous connective tissue, There was no evidence of glandular or secretory epithelial cells which could be associated with hormonal production. There were no differences in the composition of fins from juvenile and adult steelhead trout (Charlie Smith, personal communication).

Table 2. Summary of adipose fin clip quality checks at Idaho hatcheries, 1984-85.

Hatchery	Total sampled	% excellent[a]	% deep[b]	% poor[c]	% partial[d]	% unclipped[e]
Hagerman National	2,026	84.5	0.2	12.0	1.4	0.7
Niagara Springs	4,320	86.0	2.0	10.0	2.0	0.3
Dworshak National	3,601	94.8	0.0	2.4	2.0	0.7
Mean		88.4	0.7	8.1	1.8	0.6

[a]Excellent-100 removal.
[b]Deep-100 removal but secondary infection possible.
[c]Poor-less than 10% remaining.
[d]Partial-10-25% remaining.
[e]Not clipped-more than 25% remaining.

DISCUSSION

Ad Mark Operations

In the past two years all steelhead trout reared at Idaho hatcheries have received an adipose clip. This year's operations were better timed and less stressful on the fish than the previous year. The lower mortality reflects the improved conditions better than any single factor. The combined mortality for all three hatcheries was 0.3% of the total fish marked compared to 0.8% in 1984. Handling mortality decreased throughout the operation as supervisory and marking personnel became familiar with equipment and handling practices. We should experience even lower mortalities in subsequent years as personnel gain experience and improve on the present system. At this time, there are no major logistic or biological problems that should hinder the continued marking of Idaho's steelhead trout production.

Clip Quality

Random samples taken during the operations indicated an improvement in quality of the clip as personnel became more proficient. In evaluating the quality of the clip into the five categories, the rating system contains some subjectivity in estimating the percentage of the fin area remaining. If the fish are small in size (>75/lb), a very small amount of unclipped tissue may result in a poor mark. Conversely, a small portion of fin remaining on a large fish may heal into nothing more than a slight bump and result in an acceptable clip.

Those fish determined to be in the unclipped category are a result of two factors. The first is an extremely poor clip where the fin was "topped" or missed entirely. This usually happens when a few small fish are mixed with a majority of larger fish. Secondly, a fish can flip out of the markers hand and into the return pipe. This is usually because of improper anesthetization. Initial and final percentages indicate this category does not change significantly and remains less than 1% in a quality operation.

Regardless of the classification type and the percentages of the final evaluation, the "quality checks" do serve a critical need during the marking operations. They assure that a mark is being applied that can be recognized by anglers. Any fin missing over 75% of its mass is easily recognized as a clip. The quality checks indicate less than 1% of the adult hatchery steelhead trout returning to Idaho from this outmigration will have adipose fins large enough to be classified as unmarked.

Clip Healing

Healing of the area of excision is dependent on several factors including fish health, water quality and temperature, and size at clipping. Larger fish tend to expose more tissue (white area) and usually suffer higher losses due to nipping, which turns into "sore back". Less "sore back" is observed when fish are clipped at smaller sizes. Clips which are too deep expose even more tissue area and result in severe cases of nipping and "sore back". Secondary infections such as fungus also result from too deep a clip. In these cases, the fish usually never heals, and death occurs within one month.

Water temperature is critical and can be beneficial or detrimental. As a rule, fish tend to heal faster in warmer water (10 F), but fungus and secondary infections usually increase. Conversely, fish in cold water (1 to 5 C) heal more slowly, but show less signs of fungus and secondary infections. Fish marked in cold water temperatures appear to take the stress of the handling operation better, and fewer mortalities result.

In general, fish heal remarkably fast and from observed and in vivo observations, healing time is not a critical factor in the marking operation. Post-marking prophylactic treatments usually control any complication resulting from the excision of the adipose fin.

Adipose Fin Composition and Purpose

The salmonid adipose fin is relatively small, fleshy, and immobile. It does not contain any skeletal elements, is scaleless, and covered only by the dermis and epidermis. It Is filled with an amorphous matrix of loose connective tissue (Harder 1975).

Historically, the adipose fin was thought to be a vestigal fin without purpose and comprised mostly of fatty tissue and, thus, the name--adipose, Weisel (1968) found no fat in sockeye salmon (Oncorhynchus nerka) and only 3-4 drops/section in the cutthroat trout (Salmo clarki) and brown trout (Salmo trutta). In recent years, there have been several hypotheses that the fin may serve other functions ranging from hormonal regulation to pH balance. No literature to substantiate any of these hypotheses could be found. The histological examination found no evidence of glandular or secretory epithelial cells which normally are associated with endocrinal or hormonal functions. Stuart (1958) does make mention that the size and shape of the adipose fin is a secondary sex characteristic in spawning salmonids with the female fin long, thin, and narrow at the base in comparison to a short, thick, wide-based male fin.

Aleyev (1977) suggested the adipose fin in salmonids functioned basically the same as finlets in the Scombriodae (mackeral, tuna. etc.), i.e., it functions to transversely streamline the caudal peduncle for faster swimming.

Fin Regeneration

The practice of fin clipping fish for the purpose of identification has been used for many years. There are many advantages and disadvantages of this type of identification procedure. At question in all studies utilizing fin clipping is whether the fin will partially or completely regenerate, thus rendering the mark difficult to recognize at a later date. Several studies have been conducted to evaluate the regeneration of the various types of fins.

Mears (1976) studying brook trout (Salvelinus fontinalis) found regeneration had occurred in 9% of all fins observed. The frequency of regeneration was highest (41%) for the anal fin and lowest (9%) for the adipose. Regeneration of the pectoral fins was 1.5 to 2.0 times more frequent than that of pelvic fins. Few fins regenerated to more than 50% of their original size.

Johnson and Shelton (1958) found little regeneration of either adipose or pectoral fins on fall chinook at the Spring Creek Hatchery with 99.2% of all fish with a double fin mark easily identified as double-marked fish four months after marking.

Stauffer and Hansen (1969) utilized left maxillary, right maxillary, adipose, right pectoral, and right pelvic clips to mark rainbow trout. After two years in the hatchery, 95% or more of the pelvic, pectoral, and maxillary clips were recognizable (one-half or less of the fin regenerated). There was no regeneration of the adipose fin.

Shetter (1951) marked four groups of lake trout (Salvelinus namaycush) with various fin clips. The adipose clip had 5.2% regeneration, the dorsal 6.4% right pectoral 3.5%, left pectoral 10.2%, and right ventral 35.9% (one-half or more of the fin remaining). However, there appears to be some ambiguity in his reference to the quality of the clipping operation, especially for the right ventral clip.

Hale (1954) found pelvic fin regeneration to be "complete" (both fins similar and normal in size and spread) in 31.5% of the brook trout he held for 14 months 10 days, Most of the remaining fish showed "partial" (one fin club-like in appearance and the other club-like or completely regenerated) or "considerable" (one or both fins somewhat smaller and spreading like a normal fin) fin regeneration (13.7% and 47.5%, respectively). He attributed this high regeneration to inexperience and lack of skill of those clipping small fish (3.0 inches total length).

Other authors have also reported varying results, However, the various studies indicate that the adipose has the least regeneration, with the pelvics next, followed by the pectorals and anal, in respective order. In each study reviewed, a hypothes is was made that a fin with 50% remaining was regenerated. Few studies acknowledged that the regeneration could be aggravated by poor clipping technique. For

many studies, the percentage of regeneration may be nothing more than an indication of initial clip quality. Experience and results of marking juvenile salmon and steelhead for the IDFG coded-wire tagging program has shown that adipose fins properly and totally excised will not regenerate.

Examination of adult steelhead and salmon marked with an adipose clip and coded-wire tag as a juvenile indicates there is no regeneration in a complete clip and only slight regeneration of a partially clipped fin as the incision heals. However, these are usually recognizable as a clip and only when approximately 25% or less of the fin is removed does the mark become questionable. Fish marked with a coded-wire tag and left ventral clip indicate no regeneration of the clip if the fin is clipped below the basal bone. However, Leaving only a few fin rays can result in an entire but usually deformed fin. Again, the amount of regeneration is directly related to the quality of the clip. In the case of the ventral clip, a poorly applied clip usually results in the loss of information since it is difficult to differentiate a regenerated fin on a hatchery fish from the deformation the fin may received during rearing.

Stuart (1957) details pictorially the regeneration of partially clipped fins. The observations made in the coded-wire tagging program are basically in agreement with his study.

Marked Fish Survival

Experimentation utilizing marked fish assumes no differential in survival of marked fish and their unmarked counterparts they represent. However, there are studies reporting differential survival of the various clips. A differential in survival may be a result of interference with swimming abllity, endurance, behavior, or growth, Other factors such as handling during marking, physiological condition of the fish at marking, size at marking, and others may also play an important role.

Bonham (1968) concluded that a maxillary mark on chinook salmon (Oncorhynchus tshawytscha) retarded growth and probably induced mortality and was less desirable than a ventral clip, Wales (1947) found the survival of pelvic clipped fingerling brook. brown, and rainbow trout to be better than similar lots of pectoral fin clipped fish. Shetter (1951) tested the survival of lake trout receiving a single pectoral, single pelvic, or dorsal plus adipose fin clip. After correction for fin regeneration, he concluded there was no significant difference between the survival rates of the marked and unmarked fish. Armstrong (1949) found no difference in the survival rates of unmarked and adipose-clipped lake trout fingerlings after 10 months, Experiments conducted by Nelson (1960) indicated that the removal of the pelvic, adipose, or dorsal fins did not significantly affect the survival of fingerling brook or rainbow trout under hatchery conditions. Other authors such as Ricker (1949) and Foerster (1936)

found that marked fish survived significantly less than unmarked fish during their studies. In another experiment, Shetter (1952) found that fin clipped fingerling lake trout (utilizing the same clips as in his previous work) did not suffer any greater losses from predation than did unmarked fish. Horack (1969) using a stamina tunnel tested the swimming ability of 3.3 to 4.0 inch rainbow trout. He found that swimming ability was not significantly affected by removing either the dorsal) both pelvic, both pectoral, anal, or adipose fins. He concluded that the removal of both ventral or pectoral fins may reduce stamina and should be used with caution. A caudal clip severely reduced stamina and could affect the outcome of studies, Nicola and Cordone (1973) studied the long-term survival of fin clipped and unmarked rainbow trout in Castle Lake, California. They found that any fin clip was detrimental. The adipose fin clip reduced survival by as much as 50%. The removal of a ventral fin reduced survival by as much as 60% to 70%. The removal of a pectoral or dorsal fin reduced survival 70% to 80%. The removal of an anal fin was not any worse than the removal of the pectoral or dorsal, but removal had an inconsistent effect. They concluded that the anal fin clip should be avoided unless full excision could be guaranteed.

In the preliminary analysis of the Oregon Coastal Zone Management Association (OCZMA) proposal to mark hatchery-reared coho in the Oregon Production Index (OPI) area in 1984, a special task team evaluated the effects of marking. They concluded that in all experimental cases reviewed, extra handling and stress of fin clipping caused reduced survival. It also appeared that the survival effect went beyond immediate mortality due to stress in the hatchery. Although they could not identify the specific cause, evidence suggested that the removal of the adipose fin causes reduced ocean survival compared to unclipped fish. Loss of other fins or maxillary bones caused even greater losses. From the best available data, they concluded that adipose fin clipping would cause the loss of 5% to 20% of the hatchery coho production compared to unclipped releases. However, the data they present (Table 6, page 23 of the proposal), with the exception of one group, shows the adipose clip in conjunction with another mark. In almost all cases presented, the groups receiving a second mark in addition to the adipose clip survived less than the one group receiving only an adipose clip. The sources they used to estimate the 5% to 20% mortality for an adipose clip are not cited. Evidence from Idaho's fish marking, coded-wire tagging, and freeze branding operations indicates that mortality increases with each additional mark applied to the same fish.

Though there are many studies documenting marked fish survival and the differential survival between marked and unmarked fish, it appears from the literature available that the removal of the adipose fin affects survival of the fish the least followed by the pelvics, pectorals, and dorsal. The caudal, anal, and maxillary are the least desirable to use and studies indicate they may significantly affect survival.

BIBLIOGRAPHIES

The bibliographies presented are by no means complete. They are compilations from several research projects, books, and journals. Paul Mongil (1984) and Victor A.Lewynsky (1980) both have done extensive reviews of literature on hooking mortality. Their work, along with others, are included.

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LITERATURE CITED

Aleyev. 1977. Nekon. The Hague: Junk. (Reference translated and cited in R.W. Blake, 1983. Fish Locomotion).

Armstrong, G.C. 1949. Mortality, rate of growth, and fin regeneration of marked and unmarked lake trout fingerlings at the Provincial Fish Hatchery, Port Arthur, Ontario. Transactions of the American Fisheries Society 77:129-131.

Blake, R.W. 1983. Fish Locomotion. Cambridge University Press. Cambridge, Great Britain.

Bonham, K. 1968. Growth Inhibition by maxillary excision, size at start of jaw elongation, and regression of weight on length of precocious male chinook salmon, Transactions of the American Fisheries Society 97(2):198-201.

Duke, R.C. 1985, Final report, project AFS-1: Improvement of anadromous fish stocks and fisheries. Subproject 1, Study 1, Job 3: Steelhead marking trailers. Idaho Department of Fish and Game.

Foerster, R.E. 1936. The return from the sea of sockeye salmon (Oncorhynchus, nerka) with special reference to percentage survival, sex proportions and progress of migration. Journal of the Biologist Board of Canada 3(1):26-42.

Hale, J.C. 1954. Regeneration of pelvic fins on fingerling brook trout following fin clipping. Investgation Report #149, Minnesota Department of Conservation.

Harder, W. 1975. Anatomy of Fishes Part 1. Translated by Stephen Sokoloff, Tuebingen. E. Schweizerbart'sche Verlagsbuchhandlung (Magele V. Obermiller) Stuttgart.

Horack, D.C. 1969. The effect of fin removal on stamina of hatchery-reared rainbow trout. Progressive Fish-Culturist 31(4):217-220.

Hulbert, P.J., and R. Engstrom-Heg. 1980. Hooking mortalily of worm-caught hatchery brown trout. New York Fish and Game Journal 2791):1-10.

Hunsaker, D., II, L.F. Marnel I, and F.P. Sharpe. 1970. Hooking mortality of Yellowstone cutthroat trout. Progressive Fish-Cuiturist32(4):231-235.

Johnson, H.E. and J.M. Shelton. 1958. Marking chinook salmon fry. Progressive Fish-Culturist.

Mears, H.C. 1976. Overwinter regeneration of clipped fins in fingerling brook trout. The Progressive Fish-Culturist 38(2):73.

Nelson, W.C. 1960. A comparison of the effects of the removal of the adipose and pelvic fins on fingerling brook and rainbow trout. Colorado Department of Game and Fish.

Nicola, S.J. and A.J. Cordone. 1973, Effects of fin removal on survival and growth of rainbow trout (Salmo gairdneri) In a natural environment. Transactions of the American Fisheries Society 102(4):753-759.

Pettit, S.W. 1977. Steelhead catch-and-release research and regulations on the Clearwater River, Idaho. Catch-and-release fishing as a management tool. Humboldt State University, California.

Ricker, W.E. 1949. Effects of removal of fins upon the growth and survival of spiny-rayed fishes. Journal of Wildlife Management 13(1):29-40.

Shetter, D.S. 1951. The mortality and growth of marked and unmarked lake trout fingerlings in the presence of predators. Transactions of the American Fisheries Society 81:17-34.

Shetter, D.S. and L.N. Allison. 1955. Comparison of mortality between fly-hooked and worm-hooked trout in Michigan streams. Michigan Department of Conservation, Institute of Fisheries Research, Miscellaneous Publication No. 9.

Stauffer, T.M. and M.J. Hansen. 1969. Mark retention, survival, and growth of jaw-tagged and fin-clipped rainbow trout. Transactions of the American Fisheries Society 98(2):225-229.

Stuart, T.A. 1957. The migrations and homing behaviour of brown trout (Salmo trutta L.). Scientific Investigation Freshwater Fish. Scotland 18:27.

Stuart, T.A. 1958, Marking and regeneration of fins freshwater and salmon. Fishery Research, Scottish Home Department 22:14.

Wales, J.H. 1947, Growth rate and fin regeneration in trout. Progressive Fish-Culturist 9(2):86-89.

Weisel, G.F. 1968. Salmonid adipose fin. Copeia.

A P P E N D I C E S

Appendix A. BIBLIOGRAPHY - Marked Fish, Survival

Armstrong, G. C. 1947. Mortality, rate of growth, and fin regeneration of marked and unmarked lake trout fingerlings at the Provincial Fish Hatchery, Port Arthur, Ontario. Transactions of the American Fisheries Surety. 77:129-131.

Barnaby, J. T. 1944. Fluctuations in abundance of red salmon, Oncorhynchus nerka (Walbaum) , of the Karluk River, Alaska. Fishery Bulletin, United States Fish and Wildlife Service. 50(39):237-295.

Bonham, K., and L. R. Donaldson. 1966. Lowlevel chronic irradiation of salmon eggs and alevins. International Atomic Energy Agency.

Bonham, K. 1968. Growth inhibition by maxillary excision, sized at start of jaw elongation, and regression of weight on length of precocious male chinook salmon. Transactions of the American Fisheries Society. 97(2):198-201.

Brynildson, 0. M., and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society. 96(3):353-355.

Calkins, T. P. 1959. The effect of fin removal on the swimming ability of young silver salmon. University of Washington, Fisheries Research Institute, Circular 109.

Chadwick, H. K. 1966. Fish marking. A. Calhoun, editor. Inland fisheries management. California Department of Fish and Game.

Churchill, W. S. 1963. The effect of fin removal on survival, growth, and vulnerability to capture of stocked walleye fingerlings. Transactions of the American Fisheries Society. 92(3):298-300.

Coble, D. W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with review of similar investigations. Journal of Wildlife Management. 31(1):173-180.

Coble, D. W. 1972. Vulnerability of fin clipped bluegill to largemouth bass predation in tanks. Transactions of the American Fisheries Society. 101(3):563-565.

Cope, 0. B. and D. W.. Slater. 1957. Role of Coleman Hatchery in maintaining a king salmon run. United States Fish and Wildlife Service Research Report. 47:.22.

Crawford, R. W. 1958. Behaviour, growth and mortality in the bluegill, Lepomis macrochirus Rafinesque, following fin clipping. Copeia (4):330-331.

Dill, W. A., editor. 1972. Report of the symposium on the major communicable fish diseases in Europe and their control Fisheries Assistant Operation Technical Paper No. 17. Rome.

Eipper, A. W., and J. L. Forney. 1965. Evaluation of partial fin clips for marking largemouth bass, walleyes, and rainbow trout. New York Fish and Game Journal. 12(2):223-240.

Foerster, R. E. 1936. The return from the sea of sockeye salmon (Oncorhynchus nerka) with special reference to percentage survival, sex proportions and progress of migration. Journal of the Biological Board of Canada. 3(1):26-42.

Foerster, R. E. 1936. An investigations of the life history and propagation of the sockeye salmon (Oncorhynchus nerka) at Cultus Lake, British Columbia. No. 5. The life history cycle of the 1926 year class with artificial propagation involving the liberation of free-swimming fry. Journal of the Biological Board of Canada. 2(3):211-333.

Fry, D. H., Jr. 1961. Some problems in the marking of salmonids. Pacific Marine Fisheries Commission Bulletin 5:77-83.

Harris, J. E. 1936. The role of the fins in the equilibrium of the swimming fish. I. Wind tunnel tests on a model of Mustelus canis (Mitchill). Journal of Experimental Biology. 13:476-493.

Harris, J. E. 1937. The mechanical significance of the position and movements of the paired fins in the Teleostei. Papers from Tortugas Lab. Carnegie Institution of Washington. 31(7):173-189.

Harris, J. E. 1938. The role of the fins in the equilibrium of the swimming fish. II. The role of the pelvic fins. Journal of Experimental Biology 15:32-47.

Hatch, R. W., and D. A. Webster. 1961. Trout production to four central Adirondack Mountain lakes. Cornell University Agricultural Experimental Station.

Herman, E. F. 1946. Notes on the effect of cauterization in fin-clipping trout. Copeia. Issue 2.

Herman, R. L. 1968. Fish furunculosis 1952-1966. Transactions of the American Fisheries Society. 97(3):221-231.

Horack, D. C. 1969. The effect of fin removal on stamina of hatchery-reared rainbow trout. Progressive Fish-Culturist. 31(4):217-220.

Houston, A. H., J. A. Madden, R. J. Woods, and H. M. Miles. 1971. Some physiological effects of handling and tricaine methane sulphonate anesthetization upon the brook trout (Salvelinus fontinalis). Journal of Fisheries Research Board of Canada. 28(5):625-633.

Johnson, H. E., and J. M. Shelton. 1958. Marking Chinook salmon fry. Progressive Fish-Culturist. 20:183-185.

Lux, F. E. 1960. Notes of first-year growth of several species of Minnesota fish. Progressive Fish-Culturist 22(2):81-82.

Marking, L. L. 1967. Toxicity of MS-222 to selected fishes. United States Fish and Wildlife Service, Investigation of Fish Control. 12:1-10.

Mears, H. C., and R. W. Hatch. 1976. Overwinter survival, of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society. 105(6):669-674.

Mears, H. C. 1976. Effect of fin excision on survival of fingerling brook trout (Salvelinus fontinalis) in a reclaimed pond. Master's Thesis. University of Maine. Orono.

Nelson, W. C. 1960. A comparison of the effects of removal of the adipose and pelvic fins on fingerling brook and rainbow trout. Colorado Department of Game and Fish.

Nicola, S. J:, and A. J. Condone. 1973: Effects of fin removal on survival and growth of rainbow trout (Salmo gairdneri) in a natural environment Transactions of the American Fisheries Society. 102(4):753-759.

Nielson, R. S., N. Reamers, and H. D. Kennedy. 1957. A six-year study of the survival and vitality of hatchery-reared trout of catchable size in Convict Creek, California. California Fish and Game Bulletin 43:5-42.

Parker, R, R., E. C. Black and P. A. Larkin. 1961. Some aspects of fish-marking mortality. International Commission for the Northwest Atlantic Fisheries, North Atlantic Fish Marking Symposium, Woods Hole, Massachusetts. May 1961. Serial No. 828 (B. Rept. 1), Contribution No. 19.

Parker, R. R., E. C. Black, and P. A. Larkin. 1963. Some aspects of fish-marking mortality. North Atlantic Fish Marking Symposium International Commission. Northwest Atlantic Fisheries Special Publication No. 4:117-122.

Patrick, B., and R. Haas. 1971. Fin pulling as a technique for marking muskellunge fingerlings. Progressive Fish-Culturist. 33(2):116-118.

Phillips, A. M., Jr., H. A. Podoliak, D. R. Brockway, and R. R. Vaughn. 1957. The nutrition of trout. Cortland Hatchery Report 26, New York Conservation Department of Fisheries Research Bulletin 21.

Phinney, D. E., and S. B. Mathews. 1969. Field test of fluorescent pigment marking and fin-clipping of coho salmon. Journal of Fisheries Research Board of Canada. 26(6):1619-1624.

Pritchard, A. L. 1939. Homing tendency and age of maturity of pink salmon (Oncorhynchus gorbuscha) in British Columbia. Journal of Fisheries Research Board of Canada. 4(4):233-251.

Pritchard, A. L. 1941. The recovery of marked Masset Inlet pink salmon during the season of 1940. Fisheries Research Board of Canada, Program Report Pacific Coast Stations. 48:13-17.

Radcliffe, R. W. 1950. The effect of fin-clipping on the cruising speed of goldfish and coho salmon fry. Journal of Fisheries Research Board of Canada. 8(2):67-73.

Ricker, W. E. 1945. Abundance, exploitation and mortality of the fishes in two lakes. Investigation of Indiana Lakes and Streams. 2(17):345-448.

Ricker, W. E. 1948. Effects of removal of fins upon the growth and survival of spiny-rayed fishes. Journal of Wildlife Management. 13:29-40.

Ricker, W. E. 1949. Effects of removal of fins upon the growth and survival of spiny-rayed fishes. Journal of Wildlife Management. 13(1):29-40.

Robson, D. S., and H. A. Regier. 1968. Estimation of population number and mortality rates, Chap. 6 in W.E. Ricker, editor. Methods for assessment of fish production in fresh waters. International Biological Programme Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh.

Solo, E. 0. and W. H. Bayliff. 1958. Artificial and natural production of silver salmon (Oncorhynchus kisutch) at Minter Creek, Washington. Washington Department of Fisheries Research Bulletin 4:1-82.

Saunders, R. L., and K. R. Allen. 1967. Effects of tagging and of fin-clipping on the survival and growth of Atlantic salmon between smolt and adult stages. Journal of Fisheries Research Board of Canada. 24(12):2595-2611.

Schoettger, R. A., and A. M. Julin. 1967. Efficacy of MS-222 as an anesthetic on four salmonids. United States Fish and Wildlife Service. Investigation of Fish Control 13. Resource Publication 19:1-15.

Scott, B. 1968. Methods for assessment of fish production in fresh waters. International Biological Programme Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh.

Senn, H. 1970. Evaluation of 1965 brood coho released from ten Puget Sound and three coastal hatcheries. Washington Department of Fisheries, Hatcheries Division.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fisheries Bulletin 98:375.

Shatter, D. S. 1951. The effect of fin removal on fingerling lake trout (Cristivomer namaycush). Transactions of the American Fisheries Society 80:260-277.

Shatter, D. S. 1952. The mortality and growth of marked and unmarked lake trout fingerlings in the presence of predators. Transactions of the American Fisheries Society. 81:17-34.

Shatter, David S. 1967. Effects of jaw tags and fin excision upon the growth, survival, and exploitation of hatchery rainbow trout fingerlings in Michigan. Transactions of the American Fisheries Society. 96(4):394-399.

Stauffer, T. M., and M. J. Hanson. 1969. Mark retention, and survival, and growth of jaw-tagged and fin-clipped rainbow trout. Transactions of the American Fisheries Society. 98(2):255-229.

Stolte, L. W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist. 35(4):229-230.

Stuart, T. A. 1958. Marking and regeneration of fins freshwater and salmon. Fishery Research, Scottish Home Department. 22:14.

Wales, J. H. 1947. Growth rate and fin regeneration in trout. Progressive Fish-Culturist. 9(2):86-89.

Wales, J. H., and E. R. German. 1956. Castle Lake investigation-second phase: eastern brook trout. California Fish and Game Bulletin 42(2):93-108.

Weber, D., and R. G. Wahle. 1969. Effect of fin-clipping on survival of sockeye salmon (Oncorhynchus narka). Journal of Fisheries Research Board of Canada. 26(5):1263-1271.

Wolf, L. E. 1954. Development of resistant strains of fish. Transactions of the American Fisheries Society. 83:342-349.

Appendix B. BIBLIOGRAPHY - Fin Regeneration

Armstrong, G. C. 1947. Mortality, rate of growth, and fin regeneration of marked and unmarked lake trout fingerlings at the Provincial Fish Hatchery, Port Arthur, Ontario. Transactions of the American Fisheries Society. 77:129-131.

Bonham, K., and L. R. Donaldson. 1966. Low-level chronic irradiation of salmon eggs and alevins. Disposal of Radioactive Wastes into Seas, Oceans and Surface Waters. International Atomic Energy Agency.

Bonham, K. 1968. Growth inhibition by maxillary excision, size at start of jaw elongation, end regression of weight on length of precocious male chinook salmon. Transactions of the American Fisheries Society. 97(2):198-201.

Brynildson, 0. M., and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society. 96(3):353-355.

Calkins, T. P. 1959. The effect of fin removal on the swimming ability of young silver salmon. University of Washington, Fisheries Research Institute, Circular 109.

Carlander, K. D. 1953. Handbook of freshwater fishery biology. William C. Brown Company, Dubuque, Iowa.

Chadwick, H. K. 1966. Fish marking. Inland Fisheries Management. California Department of Fish and Game.

Coble, D. W. 1971. Effects of fin clipping and other factors on survival and growth of smallmouth base. Transactions of the American Fisheries Society. 100(3):460-473.

Day, F. 1887. British and Irish Salmonidae. London: Williams and Norgate.

Eipper, A. W., and J. L. Forney. 1965. Evaluation of the partial fin clips for marking largemouth bass, walleyes, and rainbow trout. New York Fish and Game Journal. 12(2):233-240.

Foerster, R. E. 1934. An investigation of the life history and propagation of the sockeye salmon (Oncorhynchus nerka) at Cultus Lake, British Columbia. No. 4. The life history cycle of the 1925 year class with natural propagation.

Foerster, R. E. 1936. An investigation of the life history and propagation of the sockeye salmon (Oncorhynchus necks) at Cultus Lake, British Columbia. No. 5. The life history cycle of the 1926 year class with artificial propagation involving the liberation of free-swimming fry. Journal of the Biological Board of Canada. 2(3):26-42.

Foerster, R. E. 1936. The return from the sea of sockeye salmon (Oncorhynchus nerka) with special reference to percentage survival, sex proportions and progress of migration. Journal of the Biological Board of Canada. 3(1):26-42.

Fry, D. H., Jr. 1961. Some problems in the marking of salmonids. Pacific Marine Fisheries Commission Bulletin. 5:77-83.

Hale, J. .C. 1954. Regeneration of pelvic fins on fingerling brook trout following fin clipping. Minnesota Department of Conservation, Investigation Report #149.

Hallock, R. J., G. H. Warner, and D. H. Fry, Jr. 1952. California's part in a three-state salmon fingerling marking program. California Fish and Game. 38(3):301-332.

Harris, J. E. 1936. The role of the fins in the equilibrium of the swimming fish. I. Wind tunnel tests on a model of Mustelus canis (Mitchill). Journal of Experimental Biology. 13:476-493.

Harris, J. E. 1937. The mechanical significance of the position and movements of the paired fins in the Teleostei. Papers from Tortugas Lab. Carnegie Institution of Washington. 31(7):173-189.

Harris, J. E. 1938. The role of the fins in the equilibrium of the swimming fish. II. The role of the pelvic fins. Journal of Experimental Biology. 15:32-47.

Hartt, A. C. 1959. Movement of salmon in the North Pacific Ocean and Bering Sea as determined by tagging. University of Washington, College of Fisheries, Circular 106.

Hartt, A. C. 1962. Movement of salmon in the North Pacific Ocean and Bering Sea as determined by tagging. Bulletin of the International North Pacific Fisheries Commission. 6:1-157.

Heacox, C. 1942. Fin regeneration in brown trout. Transactions of the American Fisheries Society. 72:231-232.

Henry, K. A. 1971. Estimates of maturation and ocean mortality for Columbia River hatchery fall Chinook salmon and effect of no ocean fishery on yield. Oregon Fisheries Commission Research Report. 3:13-27.

Herman, E. F. 1946. Notes on the effect of cauterization in fin-clipped trout. Copeia.

Horack, D. C. 1969. The effect of fin removal on stamina of hatchery-reared rainbow trout. Progressive Fish-Culturist. 31(4):217-220.

Hunter, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. Journal of the Fisheries Research Board of Canada. 16(6)5-886.

Johnson, E. H., and J. M. Shelton. 1958. Marking Chinook salmon fry. Progressive Fish-Culturist. 20(4):183-185.

Jones, J. W., and J. N. Ball. 1954. The spawning behaviour of brown trout and salmon. British Journal of Animal Behaviour. 2:103-114.

Lander, R. H., and K. A. Henry. 1973. Survival, maturity, abundance and marine distribution of 1965-66 brood coho salmon, Oncorhynchus kisutch, from Columbia River hatcheries. United States National Marine Fisheries Service, Fisheries Bulletin 71:679-695.

Lander, R. H. 1973. Problem of bias in models to approximate ocean mortality, maturity and abundance schedules of salmon from known smolts and returns. United States National Marine Fisheries Service, Fisheries Bulletin 71:513-525.

Larkin, P. A., and J. G. McDonald. 1968. Factors in the population biology of the sockeye salmon of the Skeena River. Journal of Animal Ecology. 37:229-258.

Lux, F. E. 1960. Notes on first-year growth of several species of Minnesota fish. Progessive Fish-Culturist 22(2):81-82.

Mears, H. C. 1976. Effect of fin excision on survival of fingerling brook trout (Salvelinus fontinalis) in a reclaimed pond. Master's Thesis. University of Maine.

Mears, H. C. 1976. Overwinter regeneration-of clipped fins in fingerling brook trout. Progressive Fish-Culturist. 38(2):73.

Nelson, Wesley, C. 1960. A comparison of the effects of the removal of the adipose end pelvic fins on fingerling brook and rainbow trout. Colorado Department of Game and Fish.

Nielson, R. S., N. Reimeers, and H. D. Kennedy. 1957. A six-year study of hatchery-reared trout of catchable size in Convict Creek, California. California Fish and Game Bulletin 43(1):5-42.

Parker, R. R., E. C. Black, and P. A. Larkin. 1963. Some aspects of fish-marking mortality. North Atlantic Fish Marking Symposium, International Commission North West Atlantic Fisheries Special Publication. 4:117-122.

Patrick, B., and R. Haas. 1971. Fin pulling as a technique for marking muskellunge fingerlings. Progressive Fish-Culturist. 33(2):116-118.

Phinney, D. E., and S. B. Mathews. 1969. Field teat of fluorescent pigment marking and fin-clipping of coho salmon. Journal of the Fisheries Research Board of Canada. 26(6):1619-1624.

Radcliffe, R. W. 1950. The effect of fin-clipping on the cruising speed of goldfish and coho salmon fry. Journal of the Fisheries Research Board of Canada. 8(2):67-73.

Rich, W. H., and H. B. Holmes. 1928. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. Bulletin of the United States Bureau of Fisheries. 44:215-264.

Ricker, W. E. 1946. Abundance, exploitation and mortality of the fishes in two lakes. Investigations of Indiana lakes and streams. 2(17):345-448.

Ricker. W. E. 1949. Effects of removal of fins upon the growth and survival of spiny-rayed fishes. Journal of Wildlife Management. 13(1):29-40.

Ricker, W. E. 1958. Handbook of computation for biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 119.

Robson, D. S., and H. A. Regier. 1968. Estimation of population number and mortality rates. Methods for assessment of fish production in fresh waters. International Biological Programme Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh.

Saunders, R. L., and K. R. Allen. 1967. Effects of tagging and of fin-clipping on the survival and growth of Atlantic salmon between smolt and adult stages. Journal of the Fisheries Research Board of Canada. 24(12):2595-2611.

Scott, B. 1968. Marking and tagging. Methods for assessment of fish production in fresh waters. International Biological Programme Handbook No. 3. Blackwell Scientific Publications, Oxford and Edinburgh.

Shatter, D. S. 1950. The effect of fin removal on fingerling lake trout (Cristivomer namaycush). Transactions of the American Fisheries Society. 80:260-277.

Shatter, D. S. 1951. The mortality and growth of marked and unmarked lake trout fingerlings in the presence of predators. Transactions of the American Fisheries Society. 81:17-34.

Shatter, D. S. 1967. Effects of jaw tads and fin excision upon the growth, survival arid exploitation of hatchery rainbow trout fingerlings in Michigan. Transactions of the American Fisheries Society. 96(4):394-399.

Slater, D. W, 1949. Re-formation of excised fins of king salmon fingerlings and its effects on recognition of marked adults. Transactions of the American Fisheries Society. 77:132-140.

Stauffer, T. M., and M. J. Hansen. 1969. Mark retention, survival, and growth of jaw-tagged and fin-clipped rainbow trout. Transactions of the American Fisheries Society. 98(2):225-229.

Stolte, L. W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist. 35(4):229-230.

Stuart, T. A. 1953. Spawning migration, reproduction and young stages of loch trout (Salmo trutta L.). Scientific Investigation of Freshwater Fish. 5:39.

Stuart, T. A. 1957. The migrations and homing behaviour of brown trout (Salmo trutta L.) Scientific Investigation Freshwater Fish. 18:27.

Stuart, T. A: 1958. Marking and regeneration of fins. Freshwater and Salmon Fisheries Research, Scottish Home Department. 22:14.

Taguchi, K. 1961. A trial to estimate the instantaneous rate of natural mortality of adult salmon (Oncorhynchus sp.) and the consideration of rationality of offshore fishing. I. For chum salmon (Oncorhynchus keta). Bulletin of the Japanese Society of ~~Science and Fish.~~ 27:963-971.

Wales, J. H. 1947. Growth rate and fin regeneration in trout. Progressive Fish-Culturist. 9(2):86-89.

Wales, J. H., and E. R. German. 1956. Castle Lake investigation-second phase: eastern brook trout. California Fish and Game Bulletin 42(2):93-108.

Worlund, D. D., R. J. Wahle, and P. D. Zimmer. 1969. Contribution of Columbia River hatcheries to harvest of fall Chinook salmon (Oncorhynchus _tshawytscha). United States Fish and Wildlife Service, Fishery Bulletin 67:361-391.

Appendix C. BIBLIOGRAPHY - Hooking Mortality

Adams. J. R. 1960. A catchable trait study in the Truckee River. Master's Thesis, Humboldt State College. Arcata California.

Alexander, R. 1974. Functional design in fishes. Hutchinson and Company. London, England.

Anon. 1969. A summary of information of the "shaker" catch by Washington's ocean salmon fisheries. Washington Department of Fish.

Ball, K. W. 1971. Initial effects of catch-and-release regulations on cutthroat trout in on Idaho stream. Master's Thesis, University of Idaho, Moscow, Idaho.

Barnhart, R. A., and T. D. Roelofs, editors. 1977,. Catch-and-release fishing as a management tool. Humboldt State University, California.

Benson, N. G., and R. V. Bulkley. 1963. Equilibrium yield and management of cutthroat trout in Yellowstone Lake. United States Fish and Wildlife Service, Research Report 62:44.

Beukema, ,.J. J. 1969. Angling experiments with carp (Cypinus carpio L.). I. Differences between wild, domesticated, and hybrid strains. Netherlands Journal of Zoology. 19(4):596-609.

Beukema, J. J. 1970. Acquired hook-avoidance in the pike (Esox lucius L.) fished with artificial and natural baits. Journal of Fishery Biology. 2(2):155-160.

Bjornn, T. C. 1969. Hatchery cutthroat trout hooking mortality study. Unpublished data. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, Idaho.

Bjornn, T. C., T. H. Johnson, and R. F. Thurow. 1977, Angling versus natural mortality in northern Idaho cutthroat trout populations. Catch-and-release fishing as a management tool. Humboldt State University, California.

Black, E. C. 1958. Hyperactivity as a lethal factor in fish. Journal of the Fisheries Research Board of Canada. 15:573-586.

Bouch, G. R., and R. C. Ball. 1966. Influence of capture methods an blood characteristics and mortality in the rainbow trout (Salmo gairdneri). Transactions of the American Fisheries Society. 95(2):170-176.

Brett, J. R. 1958. Implications and assessments of environmental stress. The investigation of fish-power problems. H. R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver.

Buchanan, C. C., F. J. Mather, and J. C. Mason, Jr. 1977. An overview: Cooperative game fish tagging program (Atlantic: Ocean). Catch-and-release fishing as a management tool. Humboldt State University, California.

Burns, D. C. 1977. Catch-and-release fishing for steelhead in the State of Washington. Catch-and-release fishing as a management tool. Humboldt State University, California.

Butler, R. L., and D. P. Borgenson. 1965. California "catchable" trout fisheries. Fisheries Bulletin 127, California Department of Fish and Game.

Calkins, T. P. 1959. The effect of fin removal on the swimming ability of young silver salmon. Fisheries Research Institute, University of Washington. Circular 109:6.

Carpenter, R. M., and J. M. Deinstadt. 1977. Attitudes of trout stream anglers and their relation to trout stream management. Catch-and-release fishing as a management, tool. Humboldt State University, California.

Cartwright, J. W. 1961. Hooking mortality study - caribou region - 1961. British Columbia Fish and Wildlife Branch, Management Report 50.

Casillas, E., and L. S. Smith. 1977. Effect of stress on blood coagulation and hematology in rainbow trout (Salmo qairdneri). Journal of Fisheries Biology. 10(5):481-491.

Churchill, W. S. 1963. The effect of fin removal on survival, growth, and vulnerability to capture of stocked walleye fingerlings. Transactions of the American Fisheries Society. 92:398-300.

Cleaver, F. C. 1969. Effects of Ocean fishing on 1961-brood fall chinook salmon from Columbia River hatcheries. Oregon Fisheries Commission Research Report. 1:76.

Cochran, W. G. 1977. Sampling techniques. Wiley and Sons, New York.

Cooksey, R. W., and B. L. Driver. 1977. Preferred psychological outcomes of recreational fishing. Catch-and-release fishing as a management tool. Humboldt State University, California.

Cooper, E. L. 1952. Returns from plantings of legalized brook, brown and rainbow trout in the Pigeon River, Otsego County, Michigan. Transactions of the American Fisheries Society. 82:265-280.

Cordes, R. A. 1977. The fly fisherman's view of catch-and-release fishing. Catch-and-release fishing as a management tool. Humboldt State University, California.

Cresswell, R. C. 1981. Post-stocking movements and recapture of hatchery-reared trout released into flowing waters - a review. Journal of Fisheries Biology. 18:429-442.

Deinstadt, J. M. 1977. Catch-and-release angling in California's wild trout streams. Catch-and-release fishing as a management tool. Humboldt State University, California.

Dotson, T. 1982. Mortalities in trout caused by gear type and angler-induced stress. North American Journal of Fisheries Management 2:60-65.

Folk, M. R., D. V. Gillman, and L. W. Dahlke. 1974. Comparison of mortality between barbed and barbless hooked lake trout. Environment Canada, Fisheries Marine Service, Resource Management Branch, Central Region, Technical Report Series No. CEN/T-74-1.

Folk, M. R., and D. V. Gillman. 1975. Mortality data for angled arctic grayling and northern pike from the great Slave Lake area, Northwest Territories. Environment Canada, Fisheries Marine Service, Resource Management Branch, Central Region, Data Report Series No. CEN/D 75-1.

Gowing, H. 1975. Population dynamics of wild brown trout in Gamble Creek, subject first to angling, then no angling. Fisheries Research Report No. 1824. Michigan Department of Natural Resources.

Graff, D. R. and B. A. Hollander. 1977. Catch-and-release fishing -- the Pennsylvania experience. Catch-and-release fishing as a management tool. Humboldt State University, California.

Gresswell, R. E. 1976. Hooking mortality in trout. United States Department of Interior, National Park Service, Yellowstone National Park, Informational Paper No. 29.

Griggs, J. D. 1977. Hosmer Lake -- Atlantic salmon catch-and-release program. Catch-and-release fishing as a management tool. Humboldt State University, California.

Gustaveson, A. W. 1977. Physiological response to hooking stress in largemouth bass, Micropterus salmoides. Master's Thesis, Utah State University, Logan, Utah.

Harris, J. E. 1936. The role of the fins in the equilibrium of the swimming fish. I. Wind tunnel tests on a model of Mustelus canis (Mitchill). Journal of Experimental Biology. 13:476-493.

Harris, J. E. 1937. The mechanical significance of the position and movements of the paired fins in the Teleostei. Papers from Tortugas Lab. Carnegie Institution of Washington. 31(7):173-189.

Harris, J. E. 1938. The role of the fins in the equilibrium of the swimming fish. II. The role of the pelvic fins. Journal of Experimental Biology. 15:32-47.

Hattingh,J., and A. J. J. VanPletzen. 1974. The influence of capture and transportation on some blood parameters of freshwater fish. Comparative Biochemistry Physiology. 49A:607-609.

Haw, F. 1963. Comparative hooking mortality between treble and single hooks on chinook salmon. Pacific Marine Fisheries Commission, Annual Report 15:22-24.

Heimer, J. T., W. M. Frazier, and J. S. Griffith. 1985. Post-stocking performance of catchable-size hatchery rainbow trout with and without pectoral fins. North American Journal of Fisheries Management. 5:21-25.

Helrich, L. A., and W. T. Kendall. 1982. Movements of hatchery-reared rainbow, brook and brown trout stocked in a Virginia mountain stream. The Progressive Fish-Culturist. 44:3-7.

Hollander, B. A., and D. R. Graft. 1977. Catch-and-release fishing - the Pennsylvania experience. Catch-and-release fishing as a management tool. Humboldt State University, California.

Horack, D. L., arid W. D. Klein. 1967. Influence of capture methods on fishing success, stamina, and mortality of rainbow trout in Colorado. Transactions of the American Fisheries Society. 96(2):220-222.

Hunsaker, D., II, L. F. Marnell, and F. P. Sharpe. 1970. Hooking mortality of Yellowstone cutthroat trout. Progressive Fish-Culturist. 32(4):231-235.

Hunt, R. L., 0. M. Brynildson, and J. T. McFadden. 1962. Effects of angling regulations on a wild brook trout fishery. Wisconsin Department of Natural Resources, Technical Bulletin No. 26.

Hunt, R. L. 1975. Angling regulations in relation to wild trout management. Wild Trout Management, Trout Unlimited Incorporated, Denver, Colorado.

Hunt, R. L. 1977. An unsuccessful use of catch-and-release regulations for a wild brook trout fishery. Catch-and-release fishing as a management tool, Humboldt State University, California.

Huntsman, A. G. 1938. Overexertion as a cause of death of captured fish. Science. 87(2269):577-578.

Hurn, D. R. 1961. Gold River booking mortality on summer steelhead. Unpublished data. British Columbia Fish and Wildlife Branch.

Johnson, T. H., and T. C. Bjornn. 1975. Evaluation of angling regulations in management of cutthroat trout. Job Performance Report: F-59-R-6. University of Idaho, Cooperative Fisheries Research Unit, Moscow, Idaho.

Johnson, T. H. 1977. Catch-and-release and trophy-fish regulations in the management of cutthroat trout populations and fisheries in Northern Idaho streams. Master's Thesis. University of Idaho, Moscow, Idaho.

Klein, W. D. 1969. The use of special regulations in trout stream management in Colorado. Colorado Game, Fish and Parks Division.

Klein, W. D. 1966. Mortality of trout caught on artificial lures and released by fishermen. Transactions of the American Fisheries Society. 95(3):326-328.

Klein, W. D. 1974. Mortality among trout released by anglers while ice-fishing. Unpublished Master's Thesis, Colorado State University. Colorado Division of Wildlife, Fort Collins.

Lasater, J. E., and F. Haw. 1961. Comparative hooking mortality between treble and single hooks on silver salmon. Pacific Marine Fisheries Commission. 5:73-76.

Latta, W. C. 1973. The effects of a flies-only fishing regulation upon trout in the Pigeon River, Otsego County, Michigan. Michigan Department of Natural Resources, Fisheries Division, Fisheries Research Report No. 1807.

Lennon, R. E. and P. S. Parker. 1960. The fishing-for-fun program on trout streams in Great Smoky Mountains National Park. Proceedings of the Society of the American Foresters. 1960:106-112.

MacPhee, C. 1966. Influence of differential angling mortality and stream gradient on fish abundance in a trout-sculpin biotope. Transactions of the American Fisheries Society. 95:381-387.

Marnell, L. F., and D. Hunsaker, II. 1970. Hooking mortality of lure-caught cutthroat trout (Salmo clarki) in relation to water temperature, fatigue, and reproductive maturity of released fish. Transactions of the American Fisheries Society. 99(4):684-688.

May, B. E. 1972. Evaluation of large scale release programs with special reference to bass fishing tournaments. Proceedings of the 26th Annual Conference Southeastern Association Game and Fish Commission. 26:325-329.

Mazeaud, M. M., F. Mazeaud, and E. M. Donaldson. 1977. Primary and secondary effects of stress in fish: Some new data with a general review. Transactions of the American Fisheries Society. 106:201-212.

McLaren, J., and R. L. Butler. 1970. The Spruce Creek catch-and-release study. Trout Unlimited, 11:18-19,29.

McLaren, J., and R. L. Butler. 1970. Vulnerability of wild brown trout to fly fishing under catch-and-release regulations. Master's Thesis, Pennsylvania State University.

Milne, D. J., and E. A. R. Ball. 1956. The mortality of small salmon when caught trolling and tagged or released untagged. Fisheries Research Board of Canada Program Report 106:10.-13.

Mongillo, P. E. 1976. A bioenergetic study of brown trout in a natural stream. Master's Thesis. Utah State University.

Moody, H. L. 1974. Tournament catch of largemouth bass from St. Johns River, Florida. Proceedings of the 28th Annual Conference of the Southeastern Association Game and Fish Commission. 28:73-82.

Newell, A. E. 1957. Two-year study of movements of stocked brook trout and rainbow trout in a mountain trout stream. The Progressive Fish-Culturist. 19:76-80.

Ortmann, D. W. 1976. Steelheading-just for fun? Idaho Wildlife Review. 29(1):8-10.

Parker, R. R., and E. C. Black. 1959. Muscular fatigue and mortality in troll-caught chinook salmon (Oncorhynchus tshawytscha). Journal of the Fisheries Research Board of Canada. 16:95-106.

Parker, R. R., E. C. Black, and P. A. Larkin. 1959. Fatigue and mortality in troll-caught Pacific salmon. Journal of the Fisheries Research Board of Canada. 16:429-448.

Peltzman, R. J. 1978. Hooking mortality of juvenile largemouth bass, Micropterus salmoides. California Fish and Game Bulletin 64(3):185-188.

Pettit, S. W. 1977. Steelhead catch-and-release research and regulations on the Clearwater River, Idaho. Catch-and-release fishing as a management tool. Humboldt State University, California.

Radcliffe, R. W. 1950. The effect of fin-clipping on the cruising speed of goldfish and coho salmon fry. Journal of the Fisheries Research Board of Canada. 8(2):67-73.

Reed, P. H. 1970. A review of trolling gear studies on chinook and coho salmon. Fisheries Commission of Oregon.

Rutledge, W. P. , and D. L. Pritchard. 1977. Hooking mortality of largemouth bass captured by artificial lures and natural bait. Catch-and-release fishing as a management tool. Humboldt State University, California

Seaman, E. A. 1969. Quantity vs. quality in fisheries management. Annual Conference Western Association Game and Fish Commission Proceedings. 49:60-67.

Seidensticker, E. P. 1977. Mortality of largemouth bass for two tournaments utilizing a "Don't Kill Your Catch" program. Catch-and-release fishing as a management tool. Humboldt State University, California.

Shetter, D. S. 1951. The mortality and growth of marked and unmarked lake trout fingerlings in the presence of predators. Transactions of the American Fisheries Society. 81:17-34.

Shetter, D. S., and L. N. Allison. 1958. Mortality of trout caused by hooking and artificial lures in Michigan waters, 1956-57. Michigan Department of Conservation, Institute of Fisheries Research, Miscellaneous Publication No. 12.

Shetter, D. S., and G. R. Alexander. 1962. Effects of flies-only restriction on angling and on fall trout populations in Hunt Creek, Montmorency County, Michigan. Transactions of the American Fisheries Society. 91:295-302.

Shetter, D. S., and G. R. Alexander. 1966. Angling and trout populations on the North Branch of the Au Sable River, Crawford and Otsego Counties, Michigan, under special and normal regulations, 1958-1963. Transactions of the American Fisheries Society. 95:85 91.

Shetter, D. S. 1967. Effects of jaw tags acid fin excision upon the growth, survival and exploitation of hatchery rainbow trout fingerlings in Michigan. Transactions of the American Fisheries Society 96(4):394-399.

Squire, J. L. Jr. 1977. The pacific area cooperative marine game fish tagging program for billfish - and a preliminary determination of striped marlin (Tetrapturus audax) migration patterns in the eastern Pacific. Catch-and-release fishing as a management tool. Humboldt State University, California.

Varley, J. D. 1976. Yellowstone National Park fishing regulation - biological benefits and liabilities. Annual Conference of the Western Association Game and Fish Commission, Proceedings 56:148-153.

Wallis, 0. L. 1971. Management of aquatic resources and sport fishing in national parks by special regulations. Annual Conference of the Western Association Game and Fish Commission, Proceedings 51:150-163.

Wardle, C. S. 1972. The changes in blood glucose in Pleuronectes platessa following capture from the wild: a stress reaction. Journal of Marine Biology Association of the United Kingdom. 52(3):635-651.

Warner, K. 1976. Hooking mortality of landlocked atlantic salmon (Salmo salar) in a hatchery environment. Transactions of the American Fisheries Society. 105(3):365--369.

Warner, K. 1978. Hooking mortality of lake-dwelling landlocked atlantic salmon (Salmo salar). Transactions of the American Fisheries Society. 107(4):518-522.

Warner, K., and P. R. Johnson. 1978. Mortality of landlocked atlantic salmon (Salmo salar) hooked on flies and worms in a river nursery area. Transactions of the American Fisheries Society. 107(6):772-775.

Webster, D. A., and G. S. Little. 1947. Angling experiments by the Fly Tyers' Club at Cornell University. Transactions of the American Fisheries Society. 74(1944):63-70.

Wedemeyer, G. 1970. The role of stress in the disease resistance of fishes. Symposium on disease of fishes and shellfishes. American Fisheries Society Special Publication No. 5.

Wedemeyer, G. 1972. Some physiological consequences of handling stress in the juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Journal of the Fisheries Research Board of Canada. 29:1730-1738.

Weithman, A. S., and R. 0. Anderson. 1976. Angling vulnerability of esocidae. Annual Conference Southeastern Association Game and Fish Commission, Proceedings 30:99-102.

Weithman, A. S., and R. 0. Anderson. 1977. Catch-and-release fishing for largemouth bass on Hunter's Lake - 1963-1977. Catch-and-release fishing as a management tool. Humboldt State University, California.

Wright, S. 1970. A review of the subject of hooking mortalities in pacific salmon (Oncorhynchus spp.) Washington Department of Fish.

Wydoski, R. S. 1970. Management of Washington lakes for quality fishing - the Lenice Lake study. Unpublished data. Washington Cooperative Fisheries Research Unit, University of Washington, Seattle.

Wydoski, R. S., G. A. Wedemeyer, and N. 0. Nelson. 1976. Physiological response to hooking stress in hatchery and wild rainbow trout (Salmo gairdneri). Transactions of the American Fisheries Society. 105(5):601-606.

Wydoski, R. S., and G. A. Wedemeyer. 1976. Problems in the physiological monitoring of wild fish populations. Annual Conference Western Association Game and Fish Commission, Proceedings 56:200-214.

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